The new Turbo Wing – TW propulsion for VTOL aircraft

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Abstract: *This paper relates about to a new class of propulsion systems named Turbo Wing- TW for VTOL aircraft (including civil and military drones). The idea behind this concept is to fully integrate a propulsion system into a wing structure, so that the aircraft takes full benefits of the coupling of wing aerodynamics and the propulsion thrust stream.*

Key Words: *electric aircraft, hybrid electric aircraft, VTOL, aerial vehicle, UAV, drone, advanced aircraft, turbo wing, blowing wing, propulsion, distributed electric propulsion, Advanced Aerial Mobility, AAM*

1. INTRODUCTION

Electrification of the propulsion system has opened the door to a new paradigm of propulsion system configurations and novel VTOL aircraft designs, which was never envisioned before. Furthermore, electrifying the propulsion system presents promising opportunities to enhance energy efficiency, reduce emissions, and minimize noise.

Electrical technology offers distinctive characteristics that can be harnessed to benefit from innovative propulsion concepts such as distributed electric propulsion (DEP), boundary layer ingestion (BLI), differential thrust control, and blown wing configurations. Additionally, it enables groundbreaking advancements in VTOL aircraft design by improving aero-propulsion efficiency, thanks to the flexibility of integrating thrust-producing elements across the airframe/ within the fuselage.

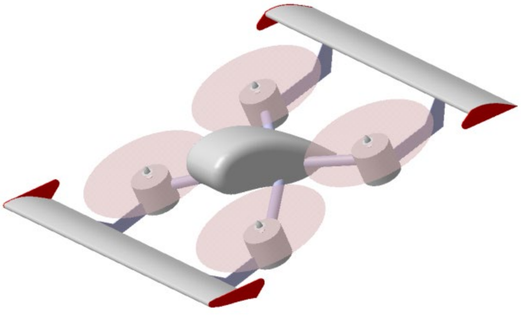
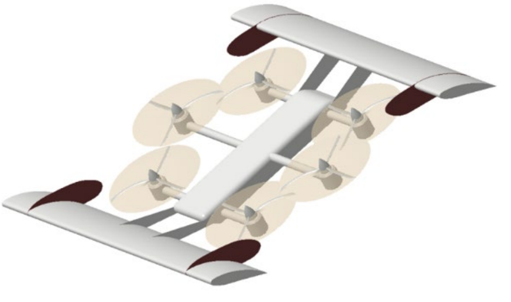
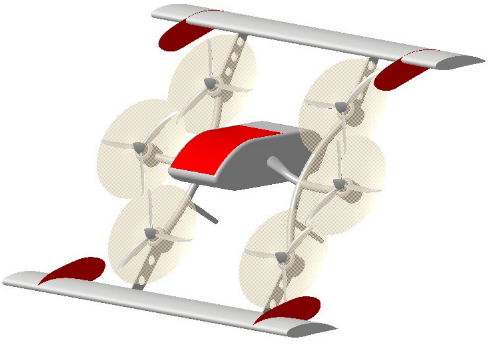
The new electric TW propulsion utilizes and even develops these new possibilities to maximize the performance of a VTOL aircraft, without increasing costs and complexity.

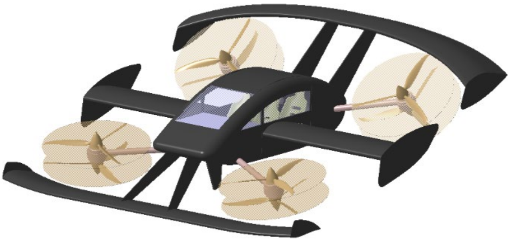
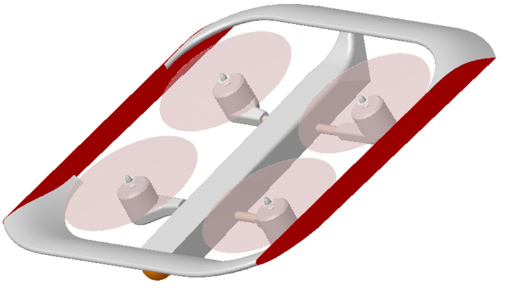
2. PATENTED TURBO WING –TW PROPULSION FOR ADVANCED VTOL AIRCRAFT

In the proposed TW configuration, the integration of the propulsion system with the aircraft's structural elements is key to achieving higher aerodynamic efficiency. A number of four, six or height propellers, positioned between the front and rear wings, are crucial in manipulating airflow dynamics.

Different TW aircraft configurations can be seen in the Table 1.

Table 1 – TW aircraft configurations

No.	Aircraft configurations	3D model	Remarks
1	Biplane TW drone with four rotors		The fuselage is aligned with the wings for better aerodynamics in horizontal flight [1]
2	Biplane TW transportation module with six rotors		It can transport different loads such as containers or passenger cabins, as in the example no. 3 [1].
3	Biplane TW passenger aircraft with six rotors		It can transport until/ up to five passengers [1].
4	Biplane TW drone with six rotors		It can be used for delivery.

5	Three-plane TW passenger aircraft with height rotors		Between 1 to 4 passengers. It can be used as first responder or as aerial ambulance aircraft [3].
6	Three-plane TW cargo drone with height rotors		It can transport standard containers for military and civil missions.
7	Biplane TW drone for ISR missions with four rotors		It can have miniature size and can be used inside buildings, tunnels, cavities, etc. [1], [2].

During operation, the front propellers generate a low-pressure zone above the front wing, while the rear propellers increase pressure beneath the rear wing. This differential pressure setup enhances lift generation, particularly valuable during the critical phase of transition. In forward flight the weight is balanced by the sum of the thrust produced by the propellers and the lift produced by the wings. The air circulation around the wings are substantially increased by the propellers with positive effects for the flight efficiency.

Preliminary validation of this aerodynamic concept was performed using Computational Fluid Dynamics -CFD simulations (Fig. 1). These studies are critical in optimizing the design by predicting how the aircraft will perform under various conditions and confirming the theoretical benefits of the TW configuration.

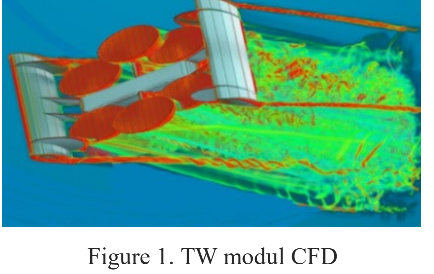


Figure 1. TW modul CFD

A first prototype of a TW drone with four rotors was achieved in a base of an existent UAV platform (Fig. 2).

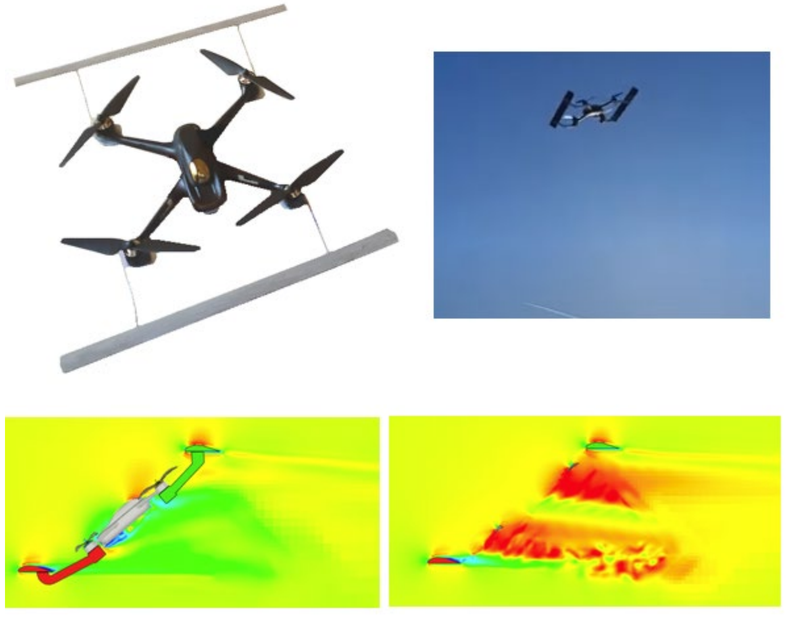


Figure 2. Flying demonstrator

Using this prototype, the first ever flight of a TW drone was completed in the spring of 2024. In the last months of the 2024 a division of SAE designated the Turbo-Wing technology as being one of the most 100 innovative technologies of the year 2024.

3. TW PROPULSION HAVING ROTORS WITH AUTOMATIC VARIAVLE PITCH

For the TW configurations with four or six rotors the flight efficiency can be further improved by using a variable pitch rotor operating automatically without external devices (Fig. 3).

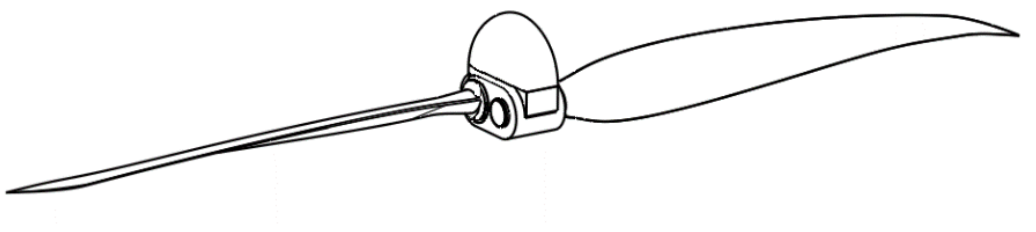


Figure 3. Variable pitch rotor

4. TW ADVANTAGES

The TW utilizes Distributed Electric Propulsion (DEP), which involves multiple electrically powered propellers distributed across the aircraft's structure. This setup not only enhances lift capabilities but also permits new flight control methodologies, such as vectored and differential thrust, which can simplify or replace traditional control surfaces. The TW design incorporates multiple rotors to increase redundancy, enhancing operational safety. The compact design and protective placement of propellers help prevent environmental contact and ensure safer interactions with ground personnel.

By eliminating traditional actuators or servos for propeller or flap adjustments, the TW system benefits from a simplified mechanical design, reducing both initial construction and ongoing maintenance costs. This simplicity also contributes to a more robust and reliable system, essential for operational durability.

Unlike traditional VTOL designs that separate propulsion and lifting systems, the TW design integrates these functions to reduce overall system complexity and improve aerodynamic performance. The configuration allows for reduced specific thrust requirements to be minimized, reducing noise levels and energy consumption. Additionally, the strategic placement of propellers enhances lift without necessarily increasing the wing area, leading to a compact yet highly efficient design.

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